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LANSCE/FMTS: The Los Alamos Neutron Science Center Fuels and Materials Test Station

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Abstract

The LANSCE/FMTS will make use of the 800 MeV, 1 mA proton accelerator at Los Alamos National laboratory to create an intense neutron source for the purpose of fuels and materials research. Proton fluxes of 4×10^{14} p/cm^2/s are achievable over small volumes for direct proton irradiation of materials. A fast neutron flux of up to 1×10^{15} n/cm^2/s is also achievable over a small volume, providing an excellent environment for fuel tests. Coolant and temperature conditions can be adjusted to the needs of the experimenters making LANSCE/FMTS a safe and versatile test facility. Irradiated materials will undergo post-irradiation examination in local hot-cells, or will be shipped to offsite locations. Pre-conceptual design, analyses and cost estimate have been completed. The goal is to implement the experiment in a time period of three years at a cost of less than $20M. The research that will be performed at the LANSCE/FMTS is in direct support of transmutation science activities in the Advanced Accelerator Applications program, the Advanced Fuel Cycle Initiative and the Gen-IV program. In addition, foreign research organizations and the fusion community have shown interest in performing irradiations.

Status

In fiscal year 2002, a pre-conceptual design, cost estimate and schedule for the implementation of the LANSCE/FMTS is being completed. The LANSCE accelerator will deliver 800 kW of beam power (800 MeV, 1mA) to a neutron producing spallation target that resides within a vacuum vessel. The chosen location for the FMTS is shown in Figures 1 thru 4. The overall vessel, shielding, and target insert configuration have been developed (figs. 4, 5), and preliminary physics analyses have been performed. The target will be a flowing Lead-Bismuth Eutectic (LBE) contained in stainless steel structures. The back-up target is water-cooled tungsten, a configuration that has been used extensively in previous target systems. Allowances will be made for the insertion of material and fuel samples directly into the LBE, making it possible to perform tests in a prototypic irradiation and coolant environment. Surrounding the target will be additional irradiation positions for direct proton irradiation (fig. 6), mixtures of protons and neutrons, and pure neutron environments with both fast and thermal spectra. The design features allow for easy insertion and retrieval of samples without target removal.

Two geometries and two target materials have been investigated. These include wing geometry, split geometry, LBE target and tungsten target. The wing geometry employs a central spallation target with fuel and material irradiation positions set to either side and in front of the target. Calculations show that for this geometry and an LBE target, the proton fluxes of 4×10^{14} p/cm^2/s are achievable and a fast neutron flux of up to 5×10^{14} n/cm^2/s in the regions to the side of the target (figs. 7 and 8). For split geometry in which the beam is deflected into two side by side target regions, the proton flux intensity is the same, but the neutron flux intensity is doublet to a value of 1×10^{15} n/cm^2/s in the center region (fig. 9), again using an LBE target. The calculations were performed assuming a fuel sample height of 11 cm. which is sufficient for meaningful testing. With the insertion of tungsten buffer plates, helium generation to displacements per atom (DPA) ratios can be varied from 1:1 to 10:1 depending on the needs of the experimenter. Calculations have also been performed using a water-cooled tungsten target in the same geometry. Proton fluxes are identical to the LBE case, but the neutron flux intensity is reduced by 25% due to the parasitic capture of the tungsten.

Both the testing of structural materials and fuels will be performed. Materials researchers will be able to investigate the irradiation effects of both protons and high energy neutrons on the structural properties of window and target materials. Materials testing in the LBE coolant will provide the synergistic effects of material corrosion and irradiation.

Over a 9 month irradiation campaign, fuels experimenters will be able to achieve burn-ups of up to 5 atom %, depending on the fuel type. Testing will be performed to understand fuel material behavior in a fast spectrum environment, and allow experimenters to test the effects of fuel composition and microstructures, swelling interaction due to fission product growth and gas retention, fuel phase stability, thermal conductivity degradation and constituent separation behavior. This research will ensure that the materials selected for fuels are phase stable under irradiation and in the presence of He and fission product accumulation. In addition to fuels tests, the experimenters will test fission product targets of technetium and iodine in prototypic environments that are an important part of the transmutation effort. With the addition of closed coolant loops, a variety of test temperatures can be achieved, and transient and overpower conditions can be imposed safely.

A regulatory compliance plan for the project has been developed. The test station activities are within the Site Wide Environmental Impact Statement. The cost and schedule for the experiment is being estimated. The current goal is to implement the experiment in a time period of three years at a cost of less than $20M. To minimize cost, an existing target location has been chosen for modification. The old target and experimental hardware will be removed, and new vacuum vessel inserted. The existing shielding (iron plates and concrete blocks) and other hardware will be used to the extent possible.

Schedule/Cost Detail

Year	Activity	Cost ($M)
FY03	Complete Design, Safety Analyses, Environmental Assessment, Authorization Basis. Perform surveys of A-1. Finalize cost estimate.	5
FY04	Place long lead procurements. Remove and dispose of A-1 target and pion beam-lines. Installation of support equipment.	8
FY05	Install vessel and target. Complete all construction. Begin commissioning.	7
Total		20

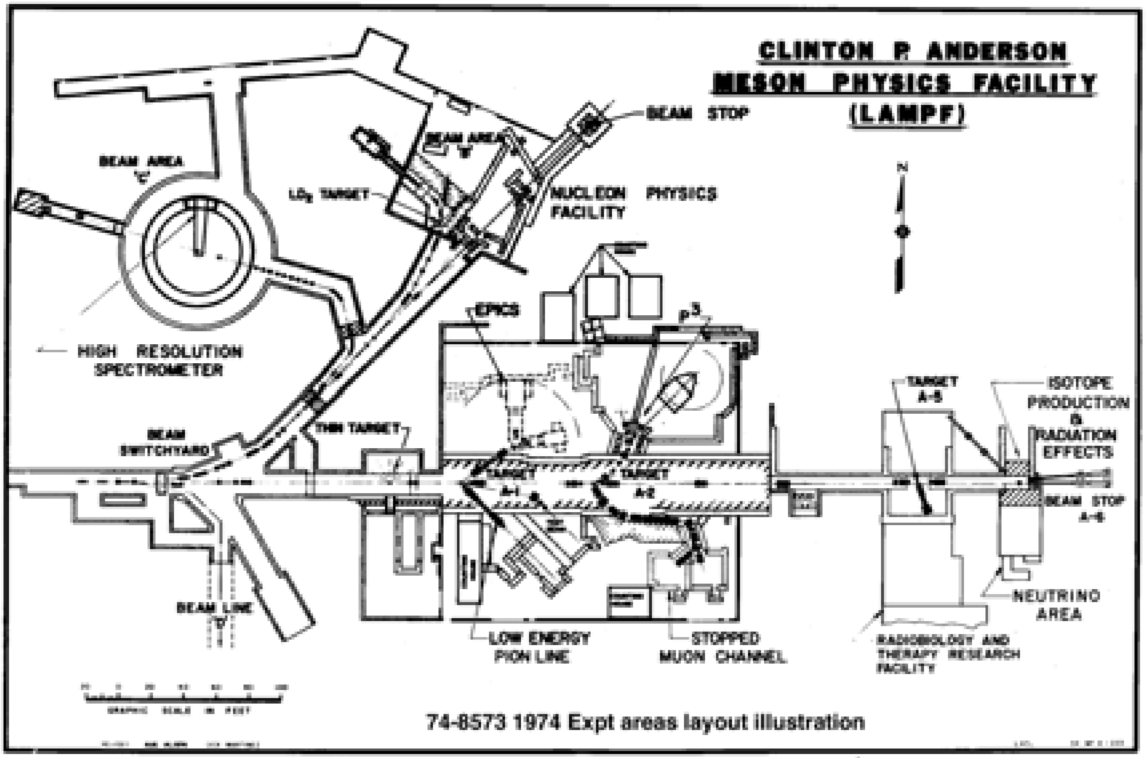

Figure 1. Area – A Detail

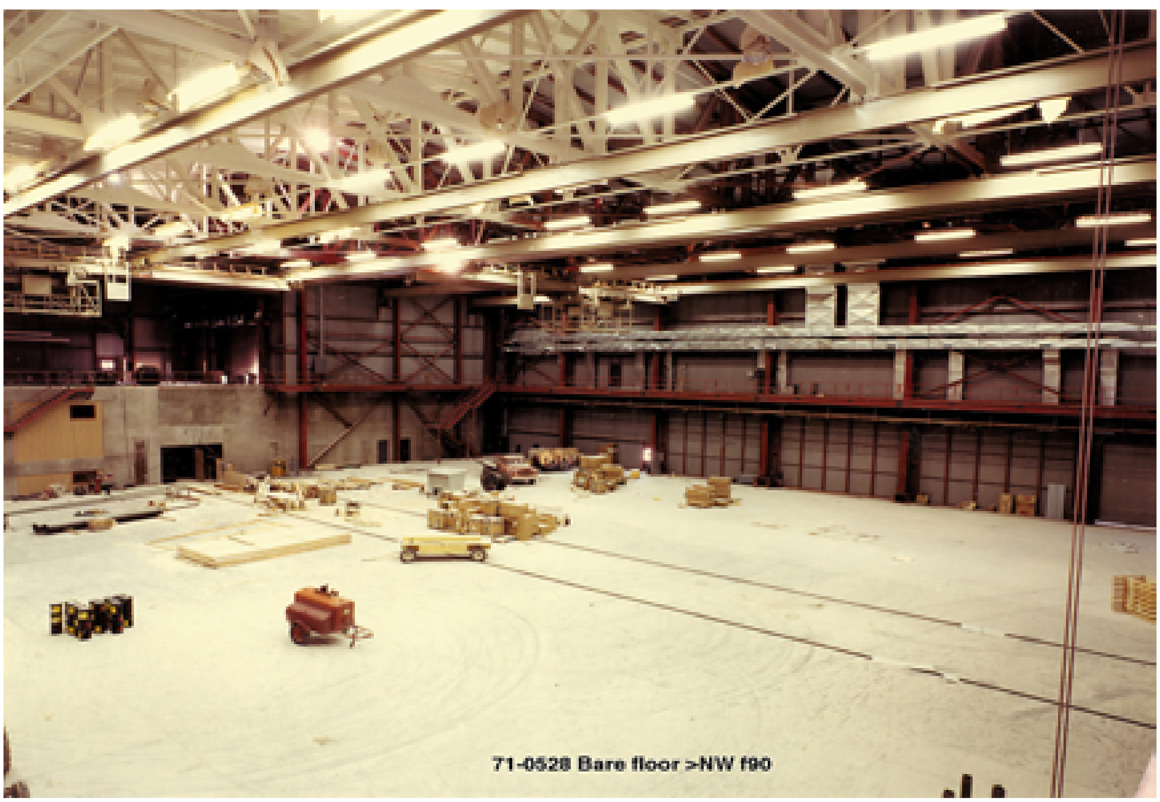

Figure 2. Area – A in 1971

Figure 3. Proposed Location at LANSCE for the FTMS

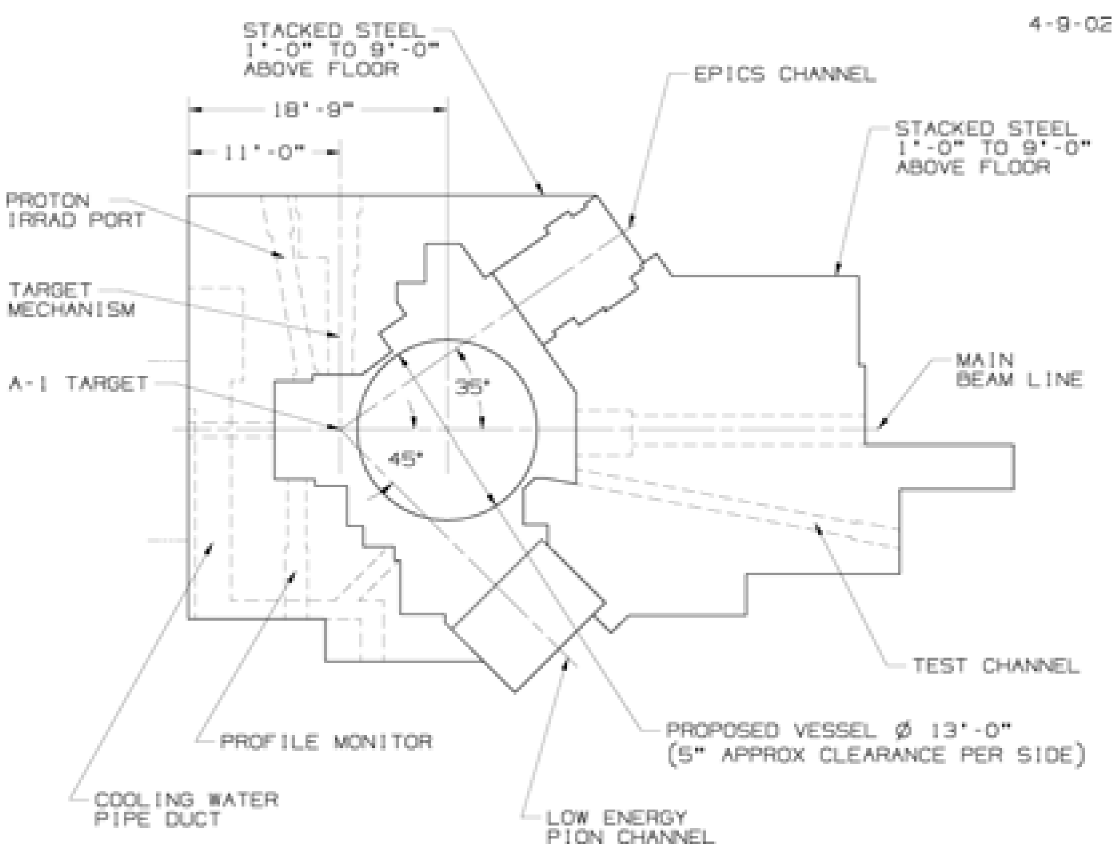

Figure 4. Vessel Location with respect to Existing Shielding

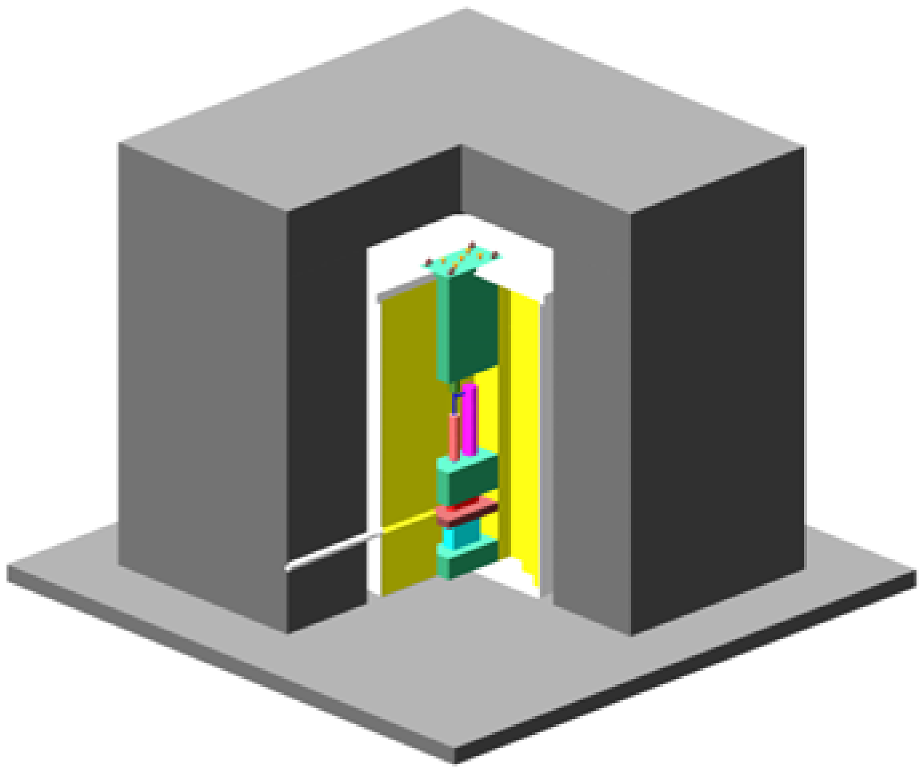

Figure 5. Vessel and Target Isometric

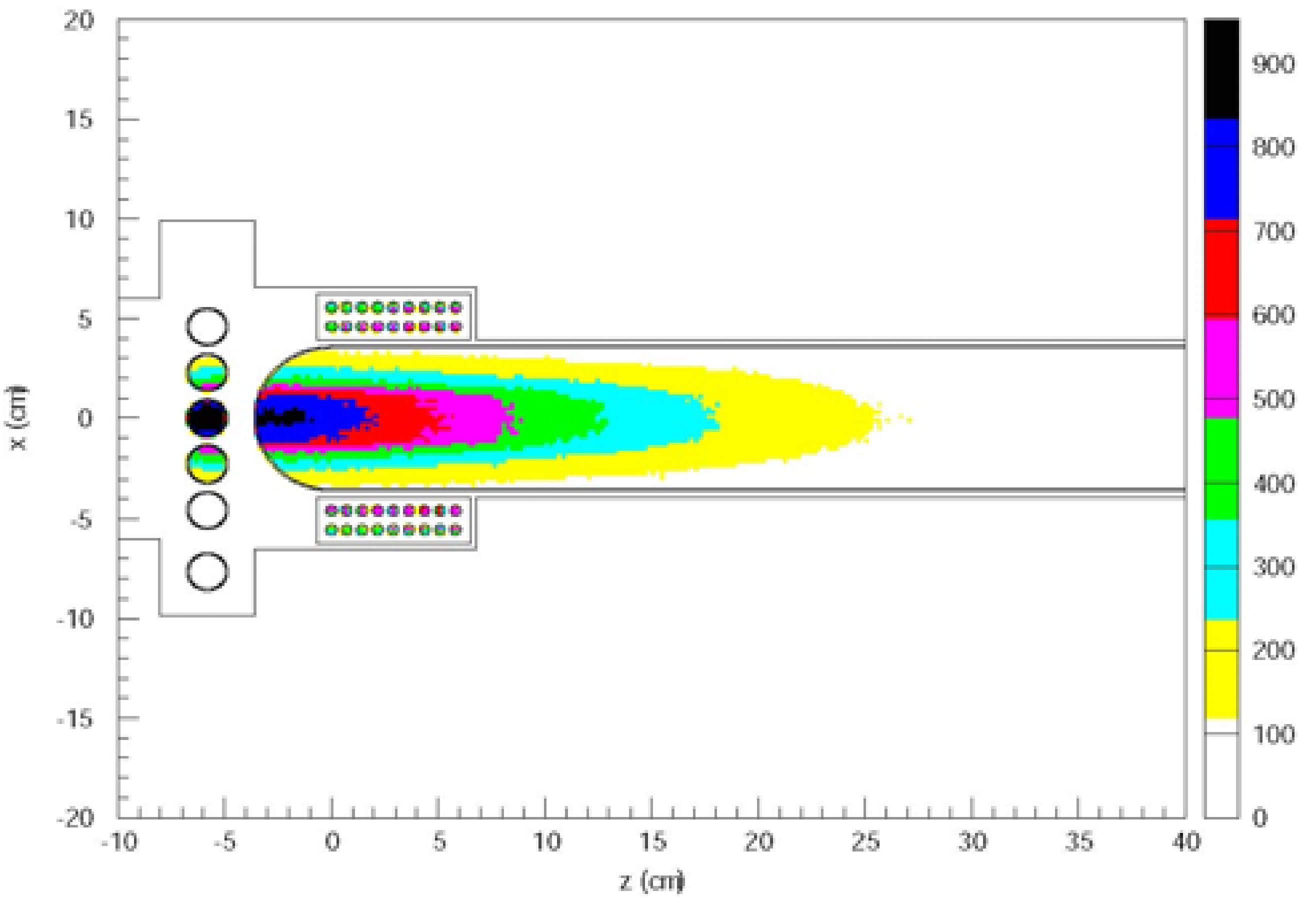

Figure 6. Wing Geometry: Energy Deposition

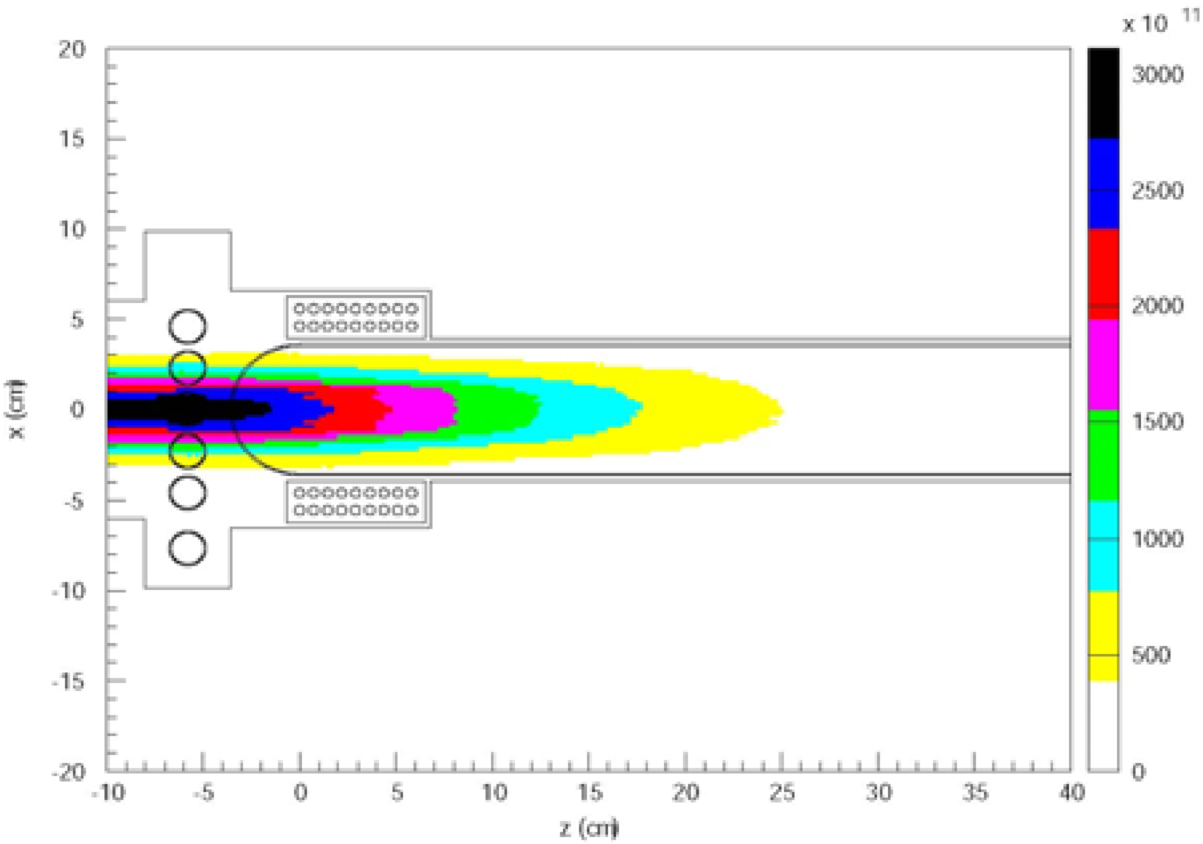

Figure 7. Wing Geometry: Proton Flux

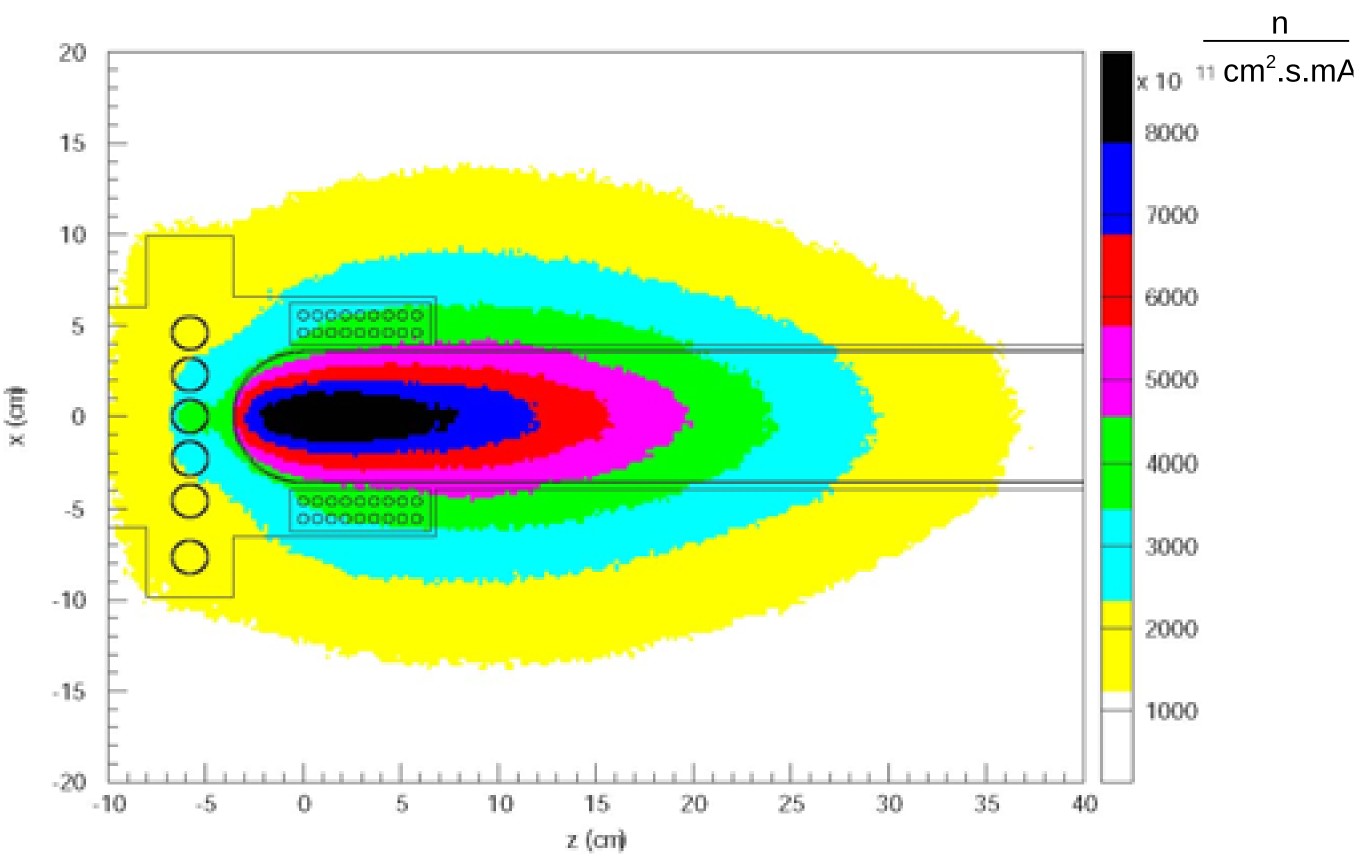

Figure 8. Wing Geometry: Fast (>0.1 MeV) Neutron Flux

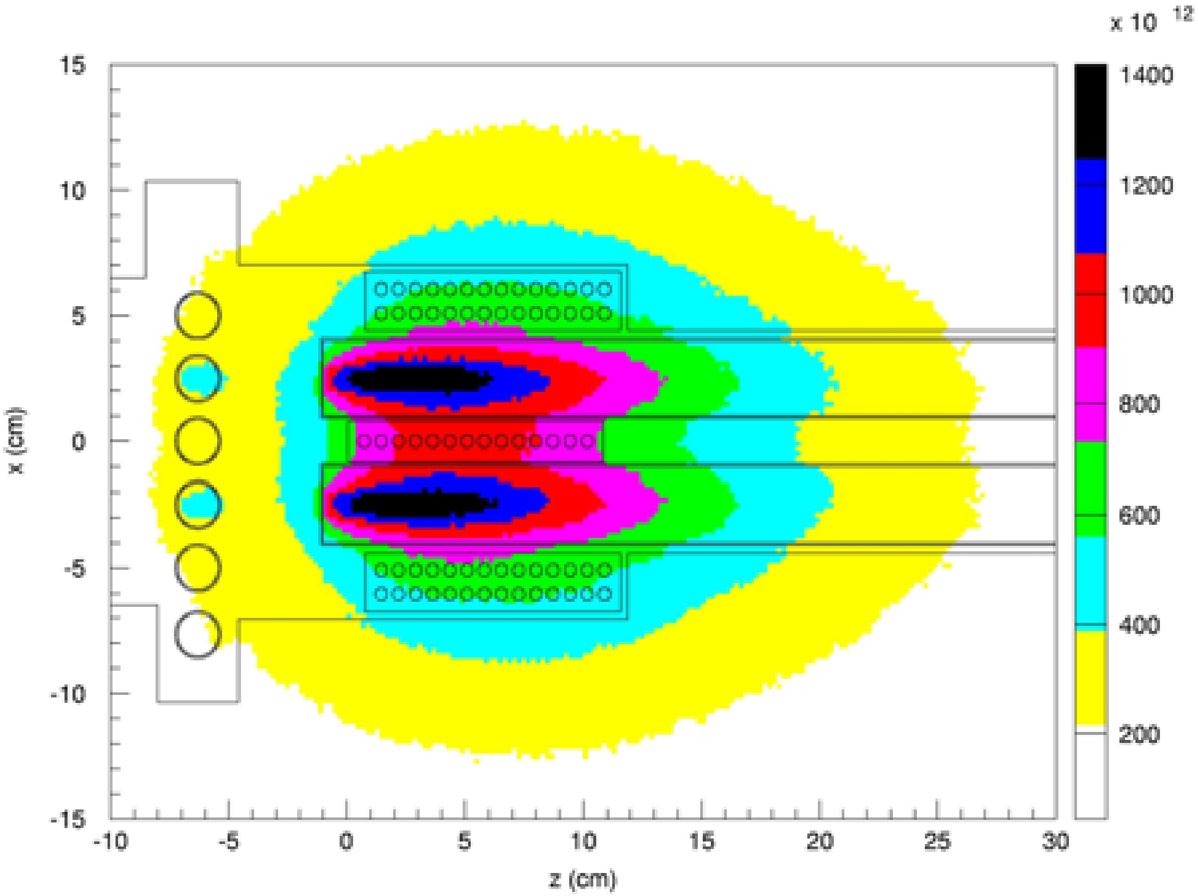

Figure 9. Split Beam Geometry: Fast (>0.1 MeV) Neutron Flux